BRAIN GAMES

Make your own Biofeedback Video Game

Ne0nRa1n
That Strange Little 'Brain Girl'

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What is old is new again!

Interest in the human brain has been around for a very long time. The first known writing on the brain is found in ancient Sumerian records from 4000 B.C, where an anonymous writer describes the euphoric mind-altering sensations caused by ingesting the common poppy plant.

Although our theories about human behavior have changed radically over the many years since, the methods of studying the brain until very recently had changed very little.

The evolution of microcomputers, miniaturization, and digital technology has changed everything as they lead us to technological advances that help us understand the human brain better.

And now as computers and electronics have become more affordable; a whole do-it-yourself neurohacking movement has emerged.

Biofeedback might sound like a throwback to the 60's and 70's - like 8 track tapes, bell bottoms or disco; but it is making a comeback. And it is no surprise in this fast-paced age where everyone seem to be trying to harness their mind/body connection for all it is worth.

Biofeedback

The definition of biofeedback

The technique of using monitoring devices to obtain information about an involuntary function of the central or autonomic nervous system, such as body temperature or blood pressure, in order to gain some voluntary control over the function. Using biofeedback, individuals can be trained to respond to abnormal measurements in involuntary function with specific therapeutic actions, such as muscle relaxation, meditation, or changing breathing patterns. Biofeedback has been used to treat medical conditions such as hypertension and chronic anxiety.

The American Heritage®
Science Dictionary

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Biofeedback devices are devices that give feedback regarding our biology. As a broad generalization something as simple as a scale that measure your weight and a thermometer that you measure your temperature with can be considered biofeedback devices because they all provide information about the state of your bodily workings.

More traditionally though, the term "*biofeedback device*" is usually used to describe equipment that shows in real-time, as it's happening, the physical effects of our thoughts, emotions, attitudes, perceptions, and mental processes.

So, different biofeedback devices would be used measure different things in your body.

How does biofeedback work?

Scientists are not able to explain exactly how or why biofeedback works. However, there does seem to be at least one common thread: most people who benefit from biofeedback have conditions that are brought on or made worse by stress.

In the late 1960s, when the term biofeedback was coined many scientists were looking forward to the day when biofeedback would give us such a major degree of control over our bodies that one day in the bright wonderful far off future it would be possible to do away with certain types of drug treatments that often caused uncomfortable side effects in patients and replace them with biofeedback since it had no negative long-term affects.

But, what scientists found is that biofeedback is not magic. It cannot cure disease, or by itself make a person healthy.

What it can do is be a highly effective and non-invasive tool to control stress by helping people observe the signals generated by their own bodies in a tangible way, and in doing so can end up helping with other problems that are linked to, or aggravated by stress.

Today, most scientists agree that such high hopes of the past were not realistic. Research has shown that we do have more control over so-called involuntary bodily function than we once though possible, but that nature will put limits on the extent of such control. Interestingly enough, scientists to this day are still trying to determine just how much voluntary control we actually can exert.

HEART RATE
AND
HEART RATE VARIABILITY

What Is Heart Rate?

Your heart rate is the number of times your heart beats per minute. You can measure your heart rate by feeling your pulse - the rhythmic expansion and contraction (or throbbing) of an artery as blood is forced through it by the regular contractions of the heart. It is a measure of how hard your heart is working.

Your pulse can be felt at area where the artery is close to the skin.

This is the part of the speech where you humour me by taking your pulse. I promise I am going somewhere with this, just stay with me.

1. Place the tips of your index, second and third fingers on the palm side of your other wrist below the base of the thumb. Or, place the tips of your index and second fingers on your lower neck on either side of your windpipe.

2. Press lightly with your fingers until you feel the blood pulsing beneath your fingers. You may need to move your fingers around slightly up or down until you feel the pulsing.

So everybody found your pulse? Good!

Now breathe normally for several seconds.

When you feel a regular pulse, exhale once, then inhale slowly and deeply.

Did you feel your heartbeat speed up slightly? What you've just felt is called respiratory sinus arrhythmia. Respiratory sinus arrhythmia is an example of normal, healthy heart-rate variability.

Heart rate variability is the pattern that emerges from tracking the time between each beat of your heart. In other words - it's the heart's ability to beat faster or slower in response to emotion or physical demands.

Why should you care?

It is important to understand the difference between these two terms if one wants to make a video game that uses biofeedback input from the heart.

In Summary:

Biofeedback is a tool that helps conditions brought on or made worse by stress

There are as many types of biofeedback

Biofeedback is not a magic bullet

Heart rate and heart rate variability are two different things: The first being the beats of your heart itself, and the other being the time in between beats.

And Now...
Joe Is Going To Talk About Some Interesting and Existing Biofeedback Things

Emotiv (www.emotiv.com) and NeuroSky (www.neurosky.com), measures various types of brain activity to control a videogame or change/enhance the state of gameplay depending on activity.

Atari Mindlink controller (www.atarimuseum.com/videogames/consoles/2600/mindlink.html), an attempt in the early 1980s to measure electrical activity of the forehead muscles

Emotiv

S00per Sekr1t pictures go here that will only be shown at the actual presentation...

Electronics in a Nutshell

You will need some basic electronics skillz before attempting to build this:

* Soldering
* Reading schematics
* Electronics assembly
* Use of test equipment (for debugging)

Even if you don't understand electronics or how the system really works, you can still build it, experiment with it, and have fun. Just don't kill yourself in the process!

Soldering

- Soldering is an art form that requires proper technique
  - With practice, you will become comfortable and experienced
  - Most hobbyists do not solder properly, which can lead to cold solder joints and bridges
- Joe's video podcast:
  www.makezine.com/blog/archive/2007/01/soldering_tutor_1.html
- Two key parts of soldering:
  - Good heat distribution from the soldering iron to the desired components
  - Cleanliness of the soldering surface and component

Reading schematics

- A *schematic* is essentially an electrical road map
- Each component of the circuit is assigned its own *symbol*

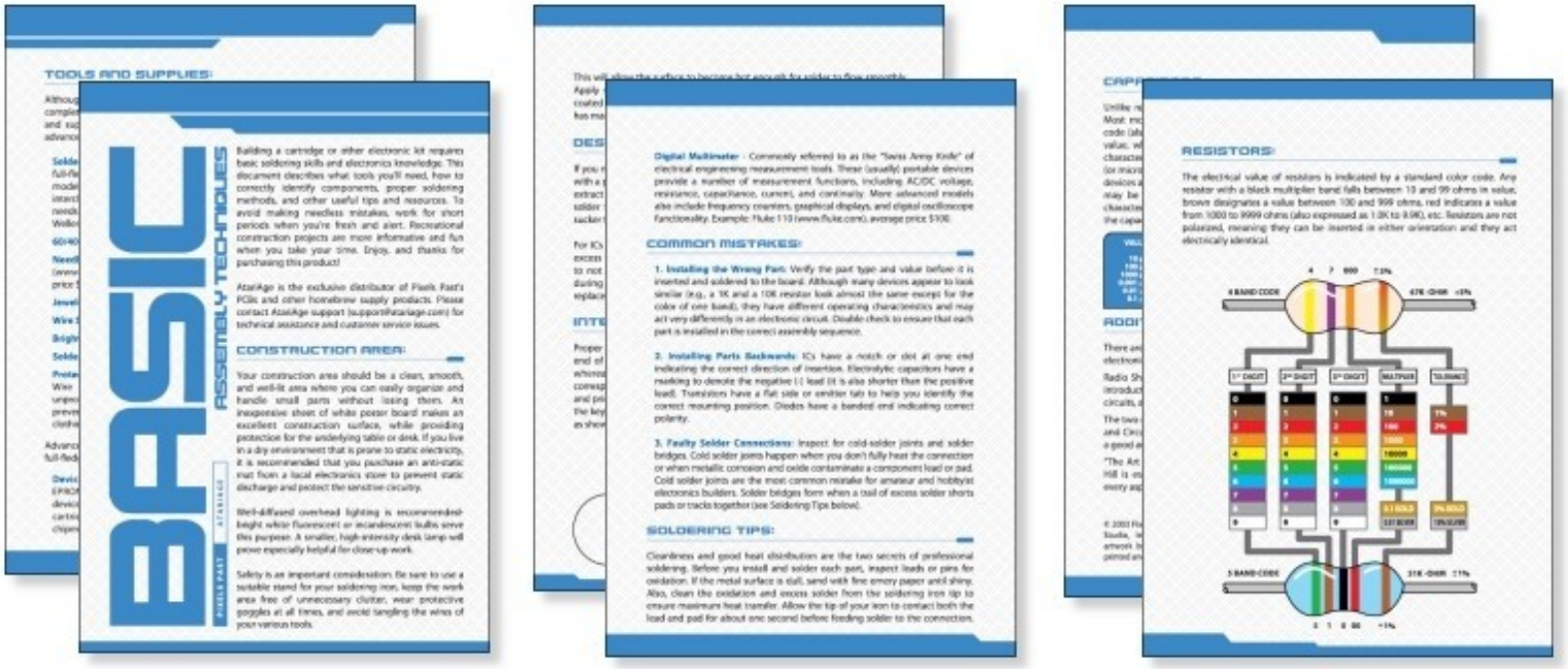
- Each symbol is unique to the type of device that it is
- Schematic symbols are like the alphabet for electronics
- The US and Europe sometimes use different symbols

- A *part designator* is also assigned to each component
  - Usually an alphabetic character followed by a numerical value
  - Ex.: R1, C4, SW2, etc.
- The schematic symbol and part designator are used together to identify each discrete component of the circuit design

Electronics assembly

- Read my "Basic Assembly Techniques" pamphlet here:

http://makezine.com/images/store/BasicAssemblyManual.pdf



Common assembly mistakes

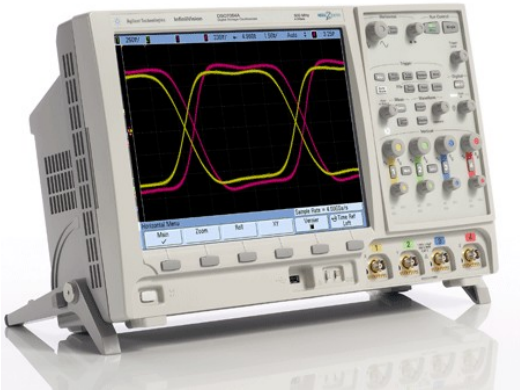
- Verify power
  - Ensure that the system is properly receiving power from the power supply or battery
  - If your device doesn't have power, chances are that it won't work!
- Faulty solder connections
  - After soldering, inspect the connections for cold solder joints and bridges
  - Cold solder joints caused by improper heating of the connection or when corrosion contaminates a component lead or pad
  - Solder bridges form when a trail of excess solder connects across pads or tracks

Common assembly mistakes (more)

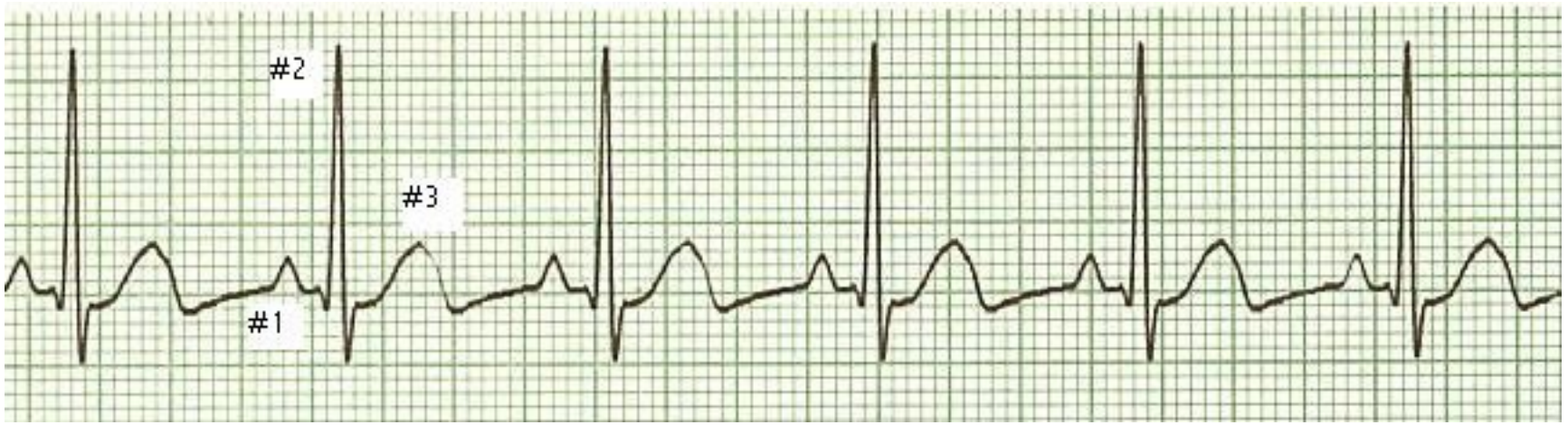
- Installing the wrong part
  - Verify the part type and value that you are using
  - Although many devices appear to look similar, they have different operating characteristics (Ex.: A 1K and 10K resistor look almost the same except for the color of one band)
- Installing parts backwards
  - Make sure your component is installed in the correct orientation
  - All polarized parts have some sort of marking identifying the positive or negative lead
  - Ex.: ICs have a dot or notch indicating pin 1, through-hole capacitors have a marking to denote the negative lead, diodes have a banded end indicating the cathode, LEDs have a flat end and short lead indicating the cathode

Test & measurement equipment

- Multimeter
  - Commonly referred to as the "Swiss army knife" of electronics measurement tools
  - Provide a number of precision measurement functions: AC/DC voltage, resistance, capacitance, current, and continuity
  - **www.makezine.com/blog/archive/2007/01/multimeter_tuto.html**
- Oscilloscope
  - Provides a visual display of electrical signals and how they change over time
  - Available in analog, digital, and mixed-mode versions
  - **www.tek.com/Measurement/App_Notes/XYZs/**



The Heart Rate Hardware



Our circuit is based on Jason Nguyen's Homemade Electrocardiograph (ECG, aka EKG), www.eng.utah.edu/~jnguyen/ecg/ecg_index.html

Simple to build

Uses a handful of parts and costs under $10

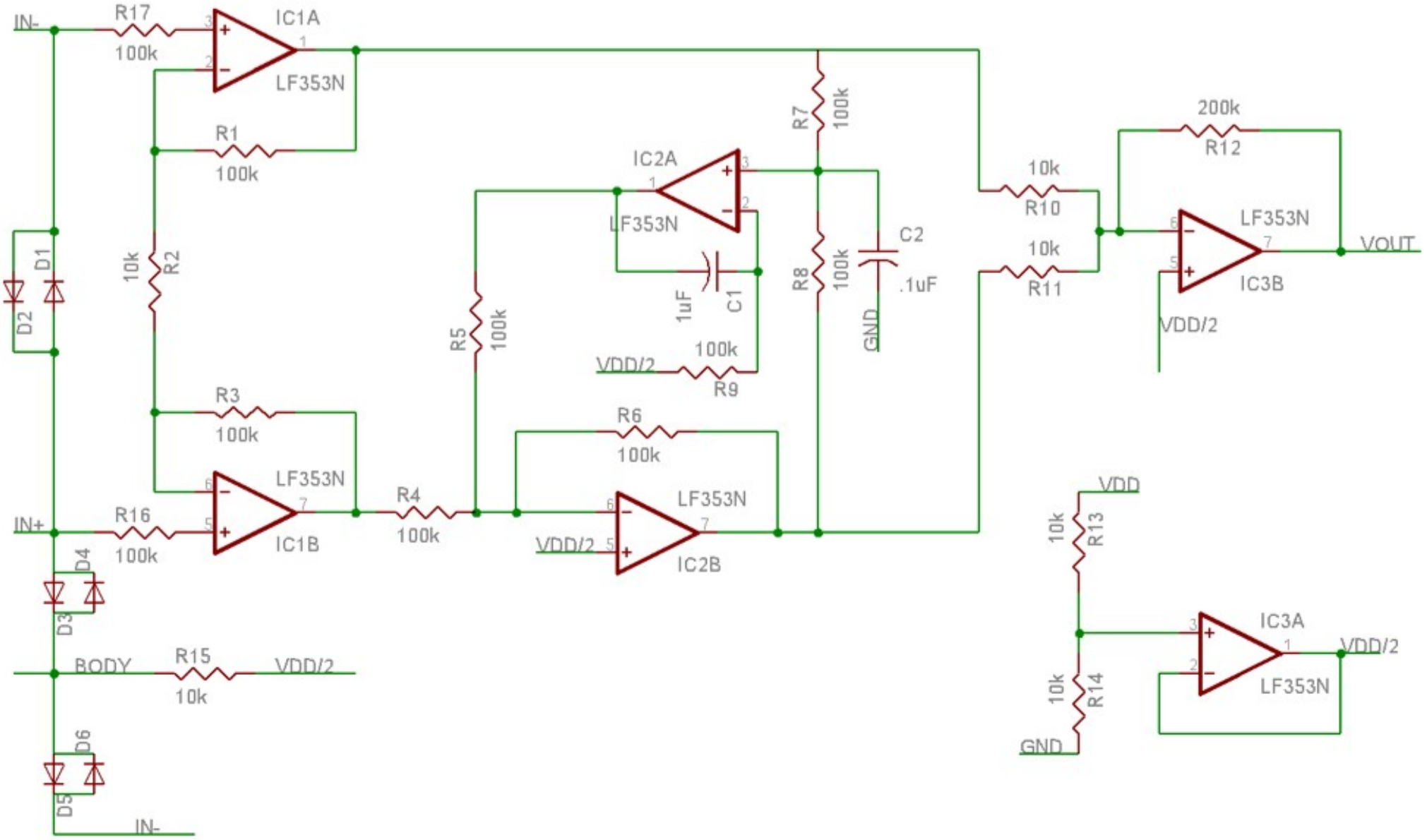
Ramsey Electronics sells a similar kit (www.ramseyelectronics.com/cgi-bin/commerce.exe?preadd=action&key=ECG1C) that you might be able to get working with our game

Parts list

All part numbers are from Digi-Key (www.digikey.com) because they're awesome

- 3x LF353N Operational Amplifier IC, 8-pin DIP (#LF353NNS-ND), $1.34 each
- 1x 500k trimmer potentiometer (#490-2928-ND), $0.86 each
- 10x 100k ohm, 1/4W, 1% resistor (#100KXBK-ND), $0.098 each
- 6x 10k ohm, 1/4W, 1% resistor (#10.0KXBK-ND), $0.098 each
- 1x 1uF ceramic capacitor, 50V, 10% (#495-3393-ND), $0.47 each
- 5x 0.1uF ceramic capacitor, 50V, 10% (#1109PHCT-ND), $0.086 each
- 6x 1N4001 general purpose rectifier diode, 50V, 1A (#1N4001DICT-ND), $0.30 each
- 1x 1/8" (3.5mm) mono phone plug (#CP3-1005-ND), $0.76 each
- 3x Pennies for electrodes, $0.01 each (you can use real, medical grade 3M Red Dots for better results)
- 1x 9V battery clip (#236K-ND), $0.49 each
- Other stuff (9V battery, wire, prototype board, etc.)

Total cost: ~$9.35



Schematic from www.eng.utah.edu/~jnguyen/ecg/ecg_index.html

- Basically, we are just measuring minute signals from the electrodes and amplifying them to levels that our PC can read via a sound card

- IN- and IN+ are the chest electrodes
- BODY serves as a common reference point
- Signals are amplified, combined into a single-ended output for sound card

- Suggested changes:

- You can replace the LF353Ns with LM324s (#296-1391-5-ND) for increased performance, but you'll need to pay attention to pinout differences
- Use 0.1uF bypass capacitors from VDD to GND and VDD/2 to GND
- We've replaced R12 with a 500k potentiometer for adjustable gain
- If the output of IC1A or IC1B is clipped, reduce gain by using a 10k resistor on R1 or R3, respectively

Now Comes the Part Where
Ne0nRa1n
Talks A Bit About The Code

All my thanks go to:

oldgrover and psychedelicbike

(They wrote this code, not me. Regardless what the media may tell you. I am not a programmer!)

This code is for proof of concept only.
(Hey, what do you expect for free?)

This code was written with you in mind so you could take it and make it your own and throw it into your favourite video games.

Why Python?
- easy for beginners who want to learn how to program and those who are experienced to be able to pick up. (Neither of the people who wrote the code knew Python before we started.)
- free
- platform independent
- someone gave me a book on Python as a gift

Why Pygame

- allows you to create fully featured games and multimedia programs in the python language
- free
- small amount of code
- simple-ish

PyMedia?

- allows you to create your own mutimedia applications
- free
 - gives you more control over use of sound then Pygame does alone.

Problems

Pymedia hasn't been tested for Macs and it can also be a terror to get to work with linux

Pygame and especially Pymedia's documentation (or I should say lack of) is not the easiest for beginner coders to wade through.

Since this code is proof of concept only it can be finicky with the hardware. Always make sure that your computer is unplugged from the wall or you'll generate too much static to be able to read a signal. Also try not to touch the electrodes they will interfer with the heart rate input.

Jumping off points

Heart rate variability

Heart rate variability can be as an indicator of different physical and psychological states than instantaneous heart rate alone.

Dynamic Difficulty Adjustment

A boring game will result in a low heart rate – make things harder. A very difficult game will result in a higher heart rate – make things easier. As the player gets better at the game, their stress level (and heart rate) will drop, so the game can automatically become more difficult to compensate for the increased player skill.

Goal Tracking

Store the heart rates to a file and observe how they change over time, with the goal of lowered average heart rate (usually indicative of healthier cardiovascular system)

The Demo

How this demo is going to work

-pick a volunteer (or two) from the audience who is of average weight and **WHO MUST BE WILLING TO TAKE THEIR SHIRT OFF** (no pacemakers allowed)

- Put electrodes on and hook up the person to the ECG program

- Get volunteer to play game while awkwardly hooked up to the electrodes

- WE ARE NOT RESPONSIBLE FOR INJURY, DEATH, OR DISMEMBERMENT! USE OUR CIRCUITRY AT YOUR OWN RISK!

Thanks!

Ne0nRa1n & Kingpin

http://www.umm.edu/altmed/articles/biofeedback-000349.htm
http://www.thorsonhealth.com/whatsnew.php
http://www.thetruthaboutfoodandhealth.com/biofeedbackdevices.html
http://psychotherapy.com/bio.html
http://www.wilddivine.com/WildDivineAboutBiofeedback/
http://findarticles.com/p/articles/mi_hb4345/is_200603/ai_n18813051
http://www.rps.psu.edu/0009/heart.html
http://my.clevelandclinic.org/heart/prevention/exercise/pulsethr.aspx
http://www.athealth.com/Practitioner/particles/Guest_CoopersteinMA.html
http://www.pbs.org/wnet/brain/history/index.html
http://www.fitsugar.com/172776
http://www.toolsforwellness.com/biofeedback.html